

# TOWARDS A RELEVANT AND SUSTAINABLE R&D AGENDA FOR TRANSPORT AND TRANSPORT INFRASTRUCTURE IN SOUTH AFRICA

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## INTRODUCTION

The importance of transport and transport infrastructure was discussed in the previous chapter. Transport and transport infrastructure plays a significant role in both economic and social development. However, in the future transport officials and engineers will need to take cognisance of the environmental impact and sustainability of transport provision.

This chapter analyses the drivers identified in the previous chapter and relates that to research, development and innovation activities world wide as well as indentified the gaps in knowledge and potential focus areas for a relevant R&D agenda in transport and transport infrastructure in South Africa.

Recent investigations into the state of South Africa's infrastructure and related policy and technology questions (SAICE 2006, Milford et al 2001) have indicated that, similarly to other countries, infrastructure in South Africa is not in good condition. In addition to the demand for environmentally friendly and sustainable solutions for transport problems, this also places emphasis on the need for key solutions to address the upgrading and maintenance of transport infrastructure.

This chapter discusses the link between the drivers that will influence the future of transport in South Africa and the potential focus areas for developing new knowledge and technological solutions summarised in main Research and Development (R&D) themes and sub-themes.

## DRIVERS, TRENDS AND ISSUES IN THE TRANSPORT INFRASTRUCTURE SECTOR

The drivers that will influence the transport industry in the future were discussed in a previous chapter. A recent technology foresight study for the construction industry in South Africa (Rust *et al* 2008) also listed a number of trends in the industry. Many of these trends are also important to the transport and transport infrastructure sectors in South Africa. These trends were evaluated and rated by a group of 50 middle managers in the construction industry. The trends ranked in order of their **longer term** importance are:

- Emphasis on environmental issues
- Increased demand on quality
- Improvement of health and safety issues
- Increase of government investment into infrastructure
- Energy shortage
- Advanced materials for infrastructure
- Water scarcity
- Demand for social infrastructure
- Increased demand for transport

- Networked systems that include sensors and systems that allow people and infrastructure to be connected
- Use of renewable resources
- Carbon taxes
- Changes in transport patterns and transport demand
- Security and crime levels
- Increasing cost of logistics
- Lack of governance and institutional capability
- Smart infrastructure including 'intelligent' products and intelligent transport systems with embedded sensors
- Lack of service delivery in South Africa
- Supply chain integration
- Prefabrication, off-site fabrication for the construction of buildings
- Increased corporate liability in the construction industry
- Intelligent urban design
- Use of Information and Communication Technology in construction
- Continued Broad Based Black Economic Empowerment

The most important of these trends for the transport sector are:

- Emphasis on environmental issues, particularly the curtailing of emissions and the use of environmentally friendly materials for transport infrastructure
- Improvement of health and safety issues, with particular emphasis on road safety
- Increase of government investment into infrastructure – significant investment is going into roads, airports and ports
- Energy shortage, with emphasis on energy efficient transport and using transport systems to generate energy
- Advanced materials for transport infrastructure, with emphasis on cement and bitumen replacements and materials that last longer
- Increased demand for transport linked to increased congestion on roads
- Networked systems that include sensors and systems that allow people and infrastructure to be connected to provide for example transport information on demand
- Use of renewable resources, particularly in the construction of transport infrastructure as well as the use of bio-fuels
- Carbon taxes that are imminent in South Africa
- Changes in transport patterns and transport demand due to changes in demographics, urbanisation etc.
- Security and crime levels particularly on public transport systems such as the Gautrain
- Increasing cost of logistics – South African cost of logistics is approximately 15% of GDP, significantly higher than that of its trading partners
- Smart infrastructure including 'intelligent' products and intelligent transport systems with embedded sensors
- Supply chain integration to reduce cost of logistics and operational costs

These longer-term trends should be considered in conjunction with the drivers discussed previously to develop a balanced portfolio of R&D focus areas for the transport sector in South Africa.

## **PROPOSED FUTURE SCIENCE AND TECHNOLOGY FOCUS AREAS**

### **The nature of R&D in the transport and transport infrastructure sectors**

R&D and new knowledge generation in the transport sector are multidisciplinary in nature, covering fields such as transport policy and planning, traffic engineering, materials science, road structural design, intelligent transport systems etc. The outputs and outcomes of research and development activities are mainly new engineering methodology, decision-support systems, prediction models, and some new hard products. The innovation process is therefore not linear, progressing from idea generation, R&D, to engineering, product manufacturing and marketing (as is mostly the case in new consumer product development), but rather an iterative, systemic process of knowledge generation and learning (Rust 2009). The development of engineering know-how and methodology is a complex, systems-related process and the management of such activity should therefore take cognisance of complexity.

Cilliers (1998) states: *“there is no denying that the world we live in is complex, and that we have to confront this complexity if we are to survive, and, perhaps, even prosper”*. The traditional way of dealing with complex issues is to engage them from what is perceived to be a scientifically determined, secure (and usually fixed) point of reference. Not only does Cilliers call this approach an avoidance of complexity, but solutions that are based on this premise will also of necessity be linear, and therefore not responsive to changes in needs and constraints. Such solutions are thus unlikely to be useful when phenomena such as human capital development and management processes need to be addressed. This is one of the reasons why the traditional linear research management models used for the development of consumer products are insufficient for the management of research, knowledge and technology development in the transport sector. R&D in the transportation field therefore requires a more holistic and systemic approach than that usually seen in hard product development processes. The R&D management model for the transport sector should therefore be based on a non-linear, systems approach (Rust 2009).

A number of the challenges faced by the transport sector are external to the sector. Changes in the nature of the demand for mobility, rising conflict and security issues, and continued population growth and urbanization are some of the challenges to be addressed. Linked with this are the growing challenges on how to ensure that environmental, economic, and social sustainability can be achieved. Technological challenges relating to aspects such as the development of alternative energy sources, improved vehicle emissions technology, improved transport infrastructure technology, and intelligent transport information and communication technologies needs to be addressed.

### **Main themes, sub-themes and focus areas for R&D**

The proposed research agendas from a number of local and international sources were analysed. These include:

- Agenda 21 for Sustainable Construction in Developing Countries (Du Plessis 2002)
- South African Department of Transport innovation and technology research strategy (DOT 2005)
- Transportek foresight study (Rust and Venter 2004)

- A review of the South African Construction Industry (CSIR 2005)
- The state of logistics survey 2008 (CSIR 2008)
- Construction 2020 – a Vision for Australia’s Construction and Property Industry (Hampson and Brandon 2004)
- Strategic Research Agenda for the European Construction Sector - Implementation Action Plan (ECTP 2007)
- Infrastructure 2007 - A global perspective (ULI 2007)
- The Strategic Highway Research Programme in the USA (TRB 2007)

From these reports as well as a number of technical discussions with industry thought leaders and researchers (Rust *et al*, 2008), the main R&D themes relating to transport infrastructure as shown below were distilled. The topics cover most of the important issues currently being viewed as important in terms of the need for R&D. These topics are at a fairly high strategic level and therefore they do not contain project-level detail.

It is also important to emphasise that the active pursuit of new knowledge generation in the areas below will lead to significant human resource development which will assist in the imperative to create built environment professionals that can satisfy the current need for high quality technical skills in South Africa.

The following R&D main themes and sub-themes were identified as important to the transport and transport infrastructure sectors:

***Sustainability of infrastructure provision and operation***

- *Environmentally responsive transport infrastructure:* recycling of road building materials, recycling of waste, recycling of construction materials
- *Sustainable neighbourhoods:* Community access roads, improved services such as public transport
- *Infrastructure investment decision:* Integrated infrastructure planning, geo-spatial planning, and technology selection to unlock social impact

***Climate change mitigation***

- *Resource efficient infrastructure:* energy efficient construction and materials, energy efficient road building materials (e.g. cool asphalt)
- *Resource efficient transport:* Alternative fuels and energy sources, traffic management systems

***Advanced construction practice***

- *Improved construction methods:* advanced methods of construction, labour-intensive construction methods, rapid construction methods

***Advanced construction materials***

- *Advanced materials for roads:* bitumen replacements, cement replacements, aggregate replacements, advanced road surfacings (e.g. thin concrete road pavements), optimisation of road materials design, nano-phosphor materials

***Advanced infrastructure design***

- *Pavement design (roads, airports, terminals):* advanced analysis methods including finite element analysis, accelerated pavement testing, dynamic road pavement performance evaluation and design methods, long-life road pavement design
- *Port design:* advanced modelling, analysis and design of ports

### **Advanced infrastructure operations**

- *Logistics:* small business logistics, humanitarian logistics, logistics modelling, solutions for improved supply chain efficiency
- *Intelligent transport systems:* sensorweb systems, advanced traffic control systems
- *Asset management systems:* road asset management, road pavement overload control
- *Traffic safety:* road accident prevention, pedestrian safety

### **Poverty alleviation through rural transport infrastructure provision**

- *Rural service provision:* Rural mobility and access roads for communities, rural development strategies, use of ICT and mobile technologies in rural logistics brokering

## **CREATING AN ENABLING ENVIRONMENT FOR R&D**

### **Historic transport related R&D programmes**

Six historic transport R&D programmes in South Africa were analysed Rust *et al* (2008b) over the period 1984 to 2007:

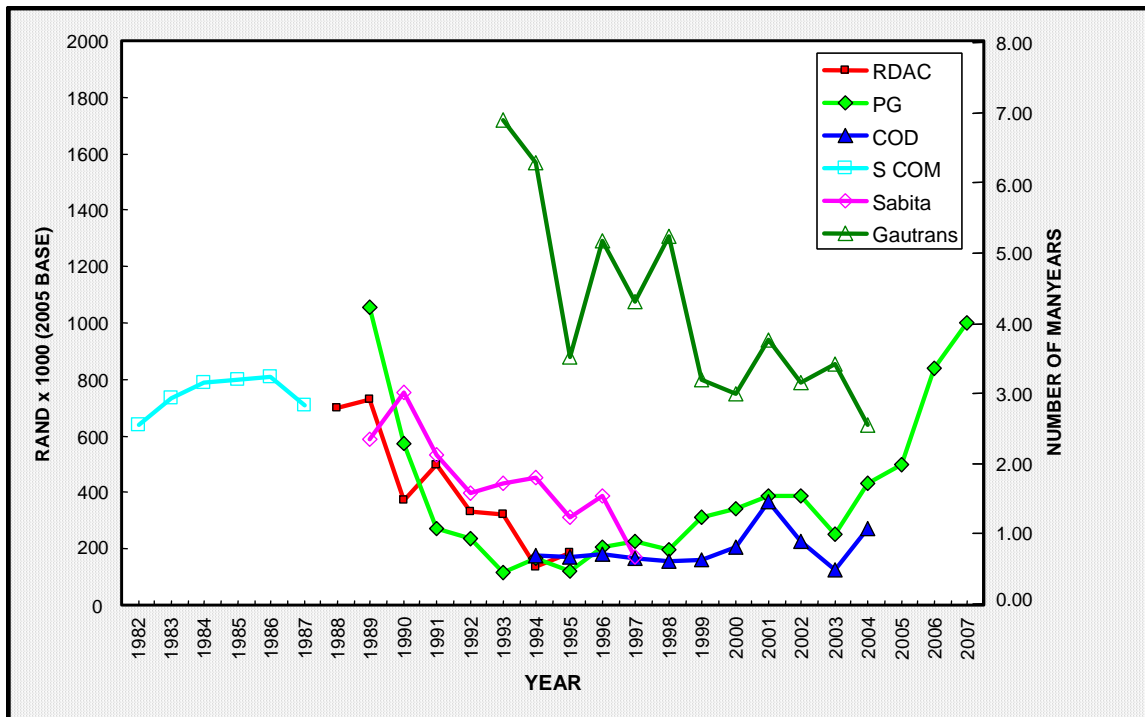
- the South African Department of Transport (DOT) research programme prior to 1988 (the Steering Committee era);
- the DOT research programme between 1988 and 1993 (the Research and Development Advisory Committee or RDAC era);
- the DOT research programme between 1993 and 1997 (the Centres of Development or CoD era);
- the Gauteng Department of Public Transport, Roads and Works (Gautrans) research programme from 1995 to 2005;
- the Southern African Bitumen Association (Sabita) research programme from 1988 to 1997, and
- the South African Council for Scientific and Industrial Research (CSIR) parliamentary grant research programme relating to transport from 1988 to 2007.

One of the main findings of this study was that the in some instances government introduced lowest-cost tendering as the procurement process for projects in the programme. This led to fragmentation of those programmes into a plethora of small projects that achieved very little output and impact (Rust *et al* 2008b). This fragmentation also had other negative effects such as:

- loss of focus by researchers;
- virtually no mentoring of junior staff by senior researchers;
- less effective peer review of research results;
- less effective technical communication;
- less effective development of human resources;
- less chance to use colleagues as a “sounding board” for ideas and evaluation of results, and

- consequently, less effective innovation and loss of research staff.

Figure 1 below shows the fragmentation in the DOT RDAC programme in terms of average project size in 2008 Rand. The graph also shows that, in most programmes in the mid 1990's, there were three projects per researcher on average thus not allowing for any mentoring of younger researchers (Rust *et al* 2008b). This is one of the major reasons why the national transport research programme in South Africa collapsed in the late 1990's. Subsequently, the national Department of Transport has not funded R&D to any level of significance.



**Figure 1: The trend in average project size of six transport R&D programmes**

The graph also shows that in the CSIR PG research programme the trend was reversed since 1998. This was due to the implementation of a systems-based R&D management model designed for the development of engineering methodology and knowledge-based products rather than consumer products.

### The current status of transport R&D funding

Transport infrastructure provision and operation is important to a number of government departments in South Africa. These include:

- The Department of Transport (DoT)
- The Department of Provincial and Local Government (DPLG) – recently split into two separate departments (Rural Development and Cooperative Governance & Traditional Affairs)
- The Department of Public Works (DPW), and
- From an SET point of view, the Department of Science and Technology (DST),

In order to understand the national situation regarding research into transport infrastructure-related topics, the medium term economic framework (MTEF 2007) budgets of these departments as well as that invested by the DST in the form of a grant to the CSIR was analysed. The result is shown in Table 2.

**Table 2: Medium term economic framework budgets for R&D activity (R x 1000)**

Department	2007/08	2008/09	2009/10
DoT R&D budget	3 000	4 000	4 000
DoT total budget	15 857 923	19 576 364	21 454 558
	0.02%	0.02%	0.02%
DPLG R&D budget	30 649	32 181	36 096
DPLG total budget	28 844 175	32 477 946	39 262 113
	0.11%	0.10%	0.09%
DPW R&D budget	0	0	0
DPW total budget	3 693 120	4 122 101	4 708 448
	0.00%	0.00%	0.00%
CSIR transport R&D	11 000	11 000	11 000
SUM OF TOTAL R&D	44 649	47 181	51 096
SUM OF TOTAL BUDGETS	48 395 218	56 176 411	65 425 119
% R&D SPEND	0.09%	0.08%	0.08%

In the MTEF budgets shown above, the figures are usually listed under Policy, Planning and Research, thus indicating that the full amount listed here is not available for research. In the case of the Department of Transport for example, only about 10% of the budgeted R30 million is currently available for actual research projects. The total amounts invested into R&D are extremely low. The South African National Research and Development Strategy (DST 2002) provides a target of one percent of GDP for R&D funding and in some circles a figure of two percent is touted as the required figure to ensure that South Africa continues to develop the knowledge and human resources required for the future. It is clear that, on average, the relevant government departments are not investing nearly enough funds into R&D.

A second problem currently experienced in R&D is the means of procurement of R&D services by government. Most departments follow the route of a strict tender process to procure R&D services. However this leads to a number of problems:

- A strict tendering process leads to over-emphasis of the lowest price, which in-turn can lead to ever decreasing project sizes with a resultant fragmentation of the research effort and associated under-delivery (Rust 2009).
- The dilemma that if a solution to a particular problem is so clear that it can be specified in a strict tendering process then the process is probably not R&D-intensive, but rather of a nature of routine service provision.
- In a call for proposals as part of an open tendering process, the R&D organisation has to put a significant amount of prior work and thinking into the development of such a proposal.

Sometimes government departments then take these proposals and ask alternative organisations to provide a “quote” for doing the work. This leads to major issues relating to the intellectual property associated with the prior thinking conducted by the original organisation.

- The above often hampers the research organisation in terms of conducting proper innovative R&D that will have significant impact.

A third problem is that, in spite of the importance of infrastructure and infrastructure-related technology, the National R&D Strategy (DST 2002) of South Africa does not address this issue clearly. The strategy does not highlight transport or transport infrastructure as an important research theme nor does it place any focus on the related professional disciplines such as civil engineering and planning. This implies that grant funding from the Department of Science and Technology is not specifically aimed at solving problems in the transport or transport infrastructure sector.

According to the National R&D Strategy of South Africa, government line departments are mainly responsible for R&D that pertains to the solving of problems in their respective sectors – so called Type 2 research. The Department of Science and Technology is responsible for more basic research (Type 1) and facilitates Type 2 research at line departments. However, the above problems as a combination put a significant hold on R&D directed at solving problems in the transport and transport infrastructure sector. This scenario leaves the sector in a position where funds for specific infrastructure-related R&D are diminishing with the consequent loss in local knowledge, expertise and skills that the country cannot afford.

### **Alternative approaches**

There are many international and some local examples of alternative approaches to the procurement of R&D services by government. These usually involve dedicated medium to long-term funding for centralised R&D organisations such as the Australian Road Research Board, the Belgian Road Research Institute, the Transport Research Laboratory in the UK etc. In the interest of brevity, this chapter will not cover the operation of these organisations in detail. However, in order to address the above scenario, the following points are offered for consideration:

- *Transport and transport infrastructure as a theme* – in view of the discussion in this paper it is concluded that R&D into infrastructure-related science and technologies in South Africa should receive a high priority in the national research agenda including those of relevant line departments such as transport as well as public works.
- *Transport foresight studies* – there is a dire need for a comprehensive transport technology foresight study that will assist in finalising the national research agenda.
- *A comprehensive national transport R&D strategy and agenda* should be developed, prioritised and funded.
- *A national forum for transport R&D co-ordination* could assist in ensuring synergy between government departments and between government and private sector in terms of developing and managing the R&D portfolio for South Africa.



- *Partnerships with private sector* are extremely important to ensure that the full innovation chain from invention to commercial application is addressed, particularly in the current scenario where the infrastructure sector is growing rapidly.
- *Improved processes for R&D procurement* need to be put in place to ensure that there is a holistic non-fragmented effort to address R&D in the infrastructure sector.
- *A centre of excellence in transport and transport infrastructure research* should be considered to ensure that critical mass in the diverse fields discussed above can be developed.

## **CONCLUDING REMARKS**

It is clear that transport and transport infrastructure is an important driver for socio-economic development and plays an essential role in poverty alleviation. At the same time, science, engineering and technology (SET) plays an essential role in the sustainable provision of transport and transport infrastructure and is indeed an important driver for the cost effective design, construction, operation and maintenance of the transport system. The fact that transport-related R&D does not feature significantly in the national R&D agenda and that funding from government departments for transport-related R&D is very low – less than 0.1 per cent of total budget compared with the target of 1 per cent in the National R&D Strategy is of concern. The current system of transport-related R&D management needs to be reviewed to allow for proper co-ordination between stakeholders (government and private sector), for ease of administration and to ensure that a comprehensive R&D agenda is developed.

The transport sector, both government and private sector, should seriously consider strategic interventions to change the current situation. Such interventions are critical for providing a sustainable transport infrastructure system and transport infrastructure that are going to be under serious pressure from the strongly growing economy and the increasing role that South Africa is playing on the continent. In addition, if South Africa wants to be a successful host of events like the soccer world cup, the situation can no longer be ignored.

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